GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT INITIATION

Date: May 22, 1978

Project Title: Consultant Services

Project No: A-2126

Project Director: Mr. S. O. Piper

Sponsor: TRACOR, Inc.; Rockville, Md. 20850

Agreement Period: From 3/30/78 Until 5/31/78(Contr. Period)

Type Agreement: P.O.#35978 (Subcontract under Prime N00039-77-C-0424)

Amount: $5,000.00

Reports Required: Final Report.

Sponsor Contact Person (s):

Technical Matters

Mr. J. McNelis
TRACOR, Inc.
1600 Wilson Blvd., #200
Arlington, Va. 22209

Contractual Matters
(thru OCA)
Ms. M. A. Regner
Purchasing Administrator
TRACOR, Inc.
1601 Research Blvd.
Rockville, Md. 20850
Phone: 301-762-7070
(Also Ms. J. A. Reitz
301-279-4200)

Defense Priority Rating: None specified.

Assigned to: Radar Instrumentation Laboratory (School/Laboratory)

COPIES TO:

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Other

CA-3 (3/76)

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GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION

Date: June 26, 1978

Project Title: Consultant Services

Project No: A-2126

Project Director: Mr. S. O. Piper

Sponsor: TRACOR, Inc.; Rockville, Md. 20850

Effective Termination Date: 5/31/78 (Contr. Expiration)

Clearance of Accounting Charges: by 5/31/78

Grant/Contract Closeout Actions Remaining:

- x Final Invoice and Closing Documents
- _ Final Fiscal Report
- _ Final Report of Inventions
- _ Govt. Property Inventory & Related Certificate
- _ Classified Material Certificate
- _ Other ____________________

Assigned to: Radar Instrumentation Laboratory (School/Laboratory)

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H-2126

ENGINEERING EXPERIMENT STATION

GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

June 6, 1978

TRACOR
Rockville, Maryland

Subject: Final Letter Report, Georgia Tech Project A-2126, TPN-22 Radar Analysis

Gentlemen:

All technical efforts under TRACOR purchase order no. 35978 have been completed. This work was initiated by a trip to the Naval Electronics System Command (NAVELEX) by Dr. William Licata and Mr. Sam Piper on 27 and 28 March 1978. Mr. Piper and Dr. Licata met with Mr. Richard Wilz of NAVALEX on the 27 March 1978, to discuss the status of the TPN-22 acceptance tests. On the 29 March 1978, Dr. Licata attended a Navy program review on the TPN-22 acceptance tests.

The meeting of 28 March 1978, was attended by:

Name	Organization
Wayne A. Essig	NAVELEX
Bud Irving	Tracor
Scott Starks	Auburn University
Ed Graf	Auburn University
Charlie Phillips	Auburn University
William Licata	Georgia Tech
John J. Gallagher	NESEA
C. K. Potyen	NESEA
Charles W. Gill	NAVELEX
S. D. Keim	NAVELEX
Lt. Col. D. J. Ogden	NAVELEX
R. A. Govoni	NAVELEX
Dick Wilz	NAVELEX

Mr. Gallagher of NESEA reported on the problems that have been encountered with the TPN-22 radar and the level of improvement in the radar tracking accuracy required to support fully automatic landings. This level of performance was based on the levels of tracking accuracy observed using the SPN-42 radar on two occasions.

It was clear from Mr. Gallagher's comments that the TPN-22 radar has been plagued by many problems. The unsatisfactory MTI display is probably the most important problem since it negates the usefulness of MTI operating mode. Proper MTI performance is essential to eliminate returns from stationary targets which enter the radar receiver through the main beam or the sidelobes. This problem is made worse by instabilities in the transmitter. The problem is the need for a 3:1 improvement in tracking accuracy. This may not be a hardware problem but a system design limitation.

Georgia Tech has conducted some analyses to help answer the question of whether the TPN-22 radar can achieve the required levels of radar tracking performance. Enclosure (1) is the output from a computer program used to estimate the tracking accuracy of a radar. The characteristics of the TPN-22 radar were entered along with some typical clutter and target characteristics. Some of the radar characteristics had to be estimated since they were not available from the TPN-22 data that Georgia Tech has in its possession. These computer results point out that the largest projected sources of tracking error are glint and scintillation. The SPN-42 radar, being an augmented system, would not suffer from these errors to the same degree as the TPN-22. It was beyond the scope of this effort to estimate what level of improvement the TPN-22 centroid tracker will provide over the accuracies computed.

The equation used in the computer program to estimate the glint error in elevation is:

$$\sigma_{el} = .35\ H_t/R \quad , \tag{1}$$

where

σ_{el} is the variance of the elevation tracking error

H_t is the height of the target

R is the range to the target.

The tracking error in azimuth is estimated using a similar equation with the target width replacing the target height. The tracking error increases with decreasing range. An augmented radar system would not suffer from this problem since the target consists of a point target. Equation (1) is based on a distributed target with several scattering centers.

The equation used to calculate the azimuth scintillation error in the computer program is:

$$\sigma_{az} = \frac{.33\ t_t \sqrt{F_s/2B_a}\ \theta_a}{t'_c} \quad , \tag{2}$$

where

t_t is the time on target

F_s is the antenna scan frequency

B_a is the antenna servo bandwidth in azimuth

θ_a is the antenna 3 dB beamwidth in azimuth

t'_c is the target decorrelation time.

Unlike the glint error, there are a number of radar parameters which influence the scintillation error. By augmenting the target, t'_c can be made large, which reduces the scintillation error.

In summation, the adequacy of the TPN-22 radar to provide mode 1 landings will be a strong function of the ability of the centroid tracker to suppress scintillation effects. The brief analysis conducted under this technical effort indicates that a substantial improvement is required to provide mode 1 landings. The two obvious solutions to this problem are to augment the target or to modify the system for monopulse tracking. It is doubtful, in Georgia Tech's opinion, that the centroid tracker will provide the desired level of performance against unaugmented aircraft.

ENCLOSURE 1

RADAR PARAM DIMENSIONS IN PAREN, NO PAREN FOR DIMENSIONLESS PARAM

PEAK POWER(KW) 120.0
ANTENNA GAIN(DB) 47.0
AZ 3DB BW(DEG) 1.1
EL 3DB BW(DEG) .7
PULSEWIDTH(MICROSEC) .25
WAVELENGTH(CM) 3.30
THERMAL FACTOR(WATTS/MHZ) .4E-14
IF BANDWIDTH(MHZ) 60.0
TRANSMIT LINE LOSS(DB) 1.0
RECEIVE LINE LOSS(DB) 1.0
PATTERN LOSS(DB) .5
IF MISMATCH LOSS(DB) 0.0
CROSSOVER LOSS(DB) 0.0
AVG SIDELOBE(DB) 18.0
ANGLE TRACK CONSTANT 1.57
PRF(PPS) 4200.0
HITS/SCAN 10.0
RANGE TRACK CONSTANT 40.00
COLLAPSING LOSS(DB) 0.0
SERVO ANGULAR ACCELERATION CONSTANT(SE -2) 90.0
SERVO ANGULAR VELOCITY CONSTANT(SE -1) 500.0
SERVO RANGE ACCELERATION CONSTANT(SE -2) 40.0
ANTENNA HEIGHT(FT) 3.0
FREQ(MHZ) 9100.0
ELEV TYPE 1
AZ TYPE 1
IPOL 1
NOISE FIGURE(DB) 3.5
SCAN FREQUENCY(HZ) 12.0
RANGE SERVO BANDWIDTH(HZ) 4.0
ANGLE SERVO BANDWIDTH(HZ) 6.0

TARGET PARAM DIMENSIONS IN PAREN, NO PAREN FOR DIMENSIONLESS PARAM

WIDTH(METERS) 7.6
LENGTH(METERS) 16.5
HEIGHT(METERS) 4.9
VELOCITY(KNOTS) 400.0
DECORRELATION TIME(MILLISEC) 1.0
CROSS SECTION(SQMETRS) 1.00
OBJ POWER SPECTRAL DENSITY (WATTS/MHZ) 0.0
OBJ MAX GAIN(DB) 6.0

SCENARIO PARAM DIMENSIONS IN PAREN, NO PAREN FOR DIMENSIONLESS PARAM

MINIMUM RANGE(NM) .50
MAXIMUM RANGE(NM) 4.00
RANGE INCREMENT(NM) .25
TARGET HEIGHT(FT) 1000.0
PROFILE OFFSET(NM) .25
TRAJECTORY TYPE 1

CLUTTER PARAM DIMENSIONS IN PAREN, NO PAREN FOR DIMENSIONLESS PARAM

RMS WAVEHEIGHT(FT)   .7
CORRELATION DISTANCE(FT)   2.8
WIND VEL(KNOTS)   10.0
BACKSCATTER COEFFICIENT(DB)   30.0
CLUTTER IMPROVEMENT FACTOR   30.0

RAIN PARAM DIMENSIONS IN PAREN, NO PAREN FOR DIMENSIONLESS PARAM

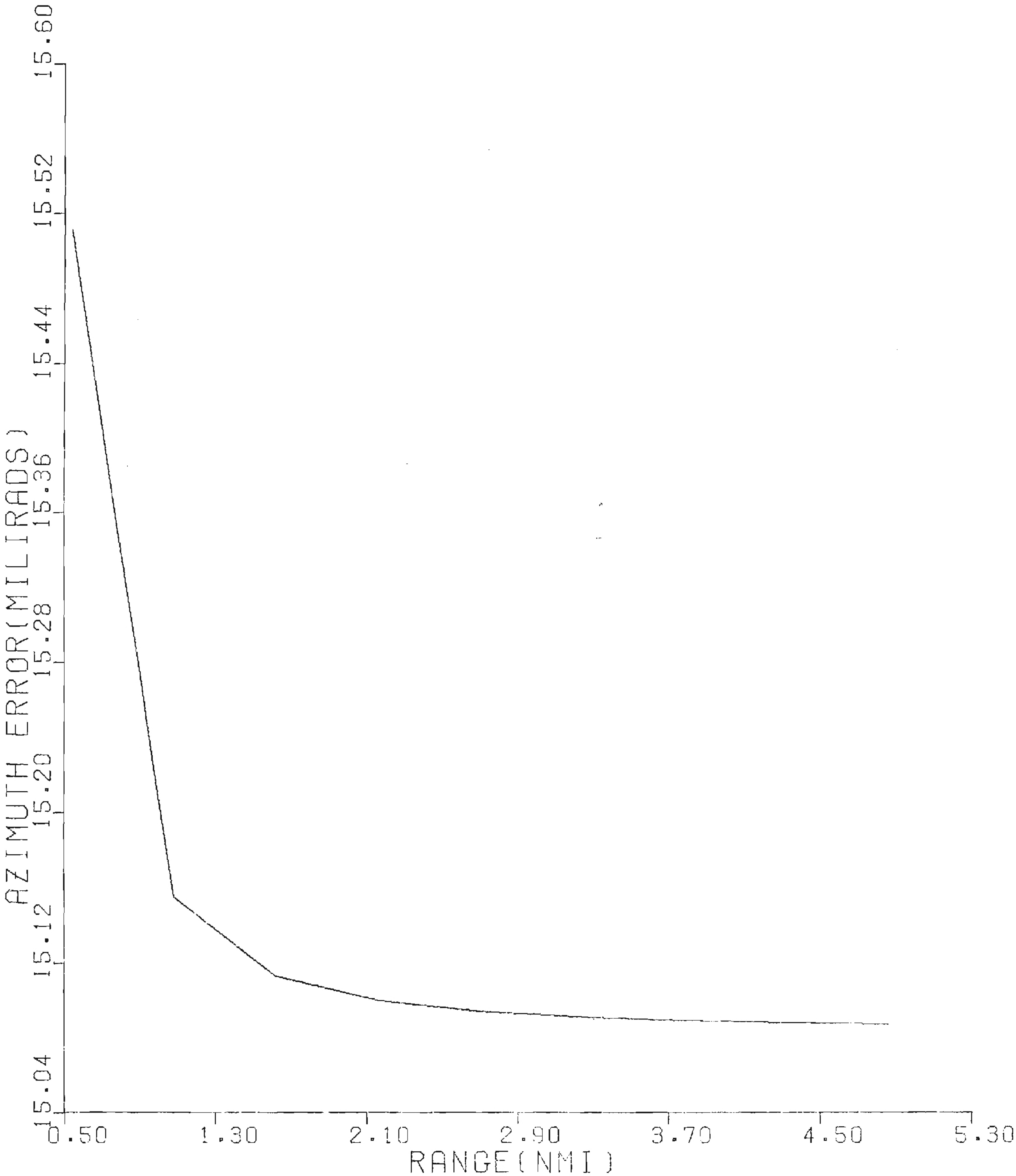
RAIN FALL RATE(MM/HR)   0.0
ABSORPTION COEFFICIENT (DB/KM)   0.0
BACKSCATTER COEFFICIENT(1/METER)   0.
BACKSCATTER IMPROVEMENT FACTOR(DB)   30.0

TRACKING ERRORS VERSUS RANGE DUE TO:

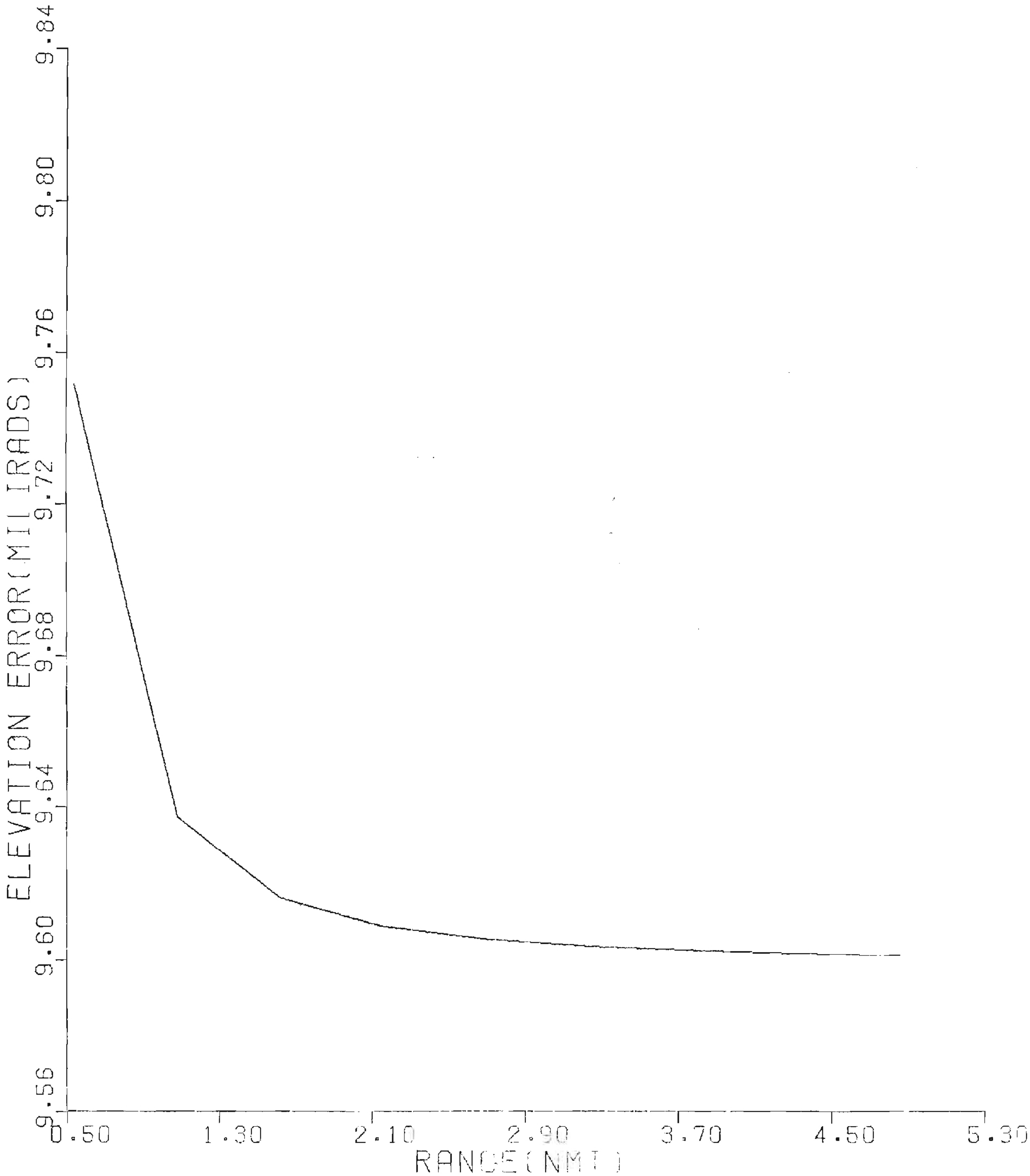
RANGE(METERS)
AZIMUTH(MILRADS)
ELEVATION(MILRADS)

RANGE(NM)	NOISE	GLINT	SERVO	CLUTTER	MULTIPATH	RAIN	SCINT	TOTAL
	.0	5.8	.0	0.0	.0	0.00		5.8
5.40	.0	.3	.0	0.0	0.0	0.00	17.8	17.8
	.0	.2	.0	0.0	.0	0.00	9.6	9.6
	.0	5.8	.0	0.0	.0	0.00		5.8
4.86	.0	.3	.0	0.0	0.0	0.00	17.8	17.8
	.0	.2	.0	0.0	.0	0.00	9.6	9.6
	.0	5.8	.0	0.0	.0	0.00		5.8
4.32	.0	.3	.0	0.0	0.0	0.00	17.8	17.8
	.0	.2	.0	0.0	.0	0.00	9.6	9.6
	.0	5.8	.0	0.0	.0	0.00		5.8
3.78	.0	.4	.0	0.0	0.0	0.00	17.8	17.8
	.0	.2	.0	0.0	.0	0.00	9.6	9.6
	.0	5.8	.0	0.0	.0	0.00		5.8
3.24	.0	.4	.0	0.0	0.0	0.00	17.8	17.8
	.0	.3	.0	0.0	.0	0.00	9.6	9.6
	.0	5.8	.0	0.0	.0	0.00		5.8
2.70	.0	.5	.0	0.0	0.0	0.00	17.8	17.8
	.0	.3	.0	0.0	.0	0.00	9.6	9.6
	.0	5.7	.0	.0	.0	0.00		5.7
2.16	.0	.7	.0	.0	0.0	0.00	17.8	17.8
	.0	.4	.0	.0	.0	0.00	9.6	9.6
	.0	5.7	.0	.0	.0	0.00		5.7
1.62	.0	.9	.0	.0	0.0	0.00	17.8	17.8
	.0	.6	.0	.0	.0	0.00	9.6	9.6
	.0	5.7	.0	.0	.0	0.00		5.7
1.08	.0	1.5	.1	.0	0.0	0.00	17.8	17.8
	.0	.9	.0	.0	.0	0.00	9.6	9.6
	.0	5.3	.2	.0	.0	0.00		5.3
.54	.0	3.6	.6	.0	0.0	0.00	17.8	18.1
	.0	1.7	.1	.0	.0	0.00	9.6	9.8

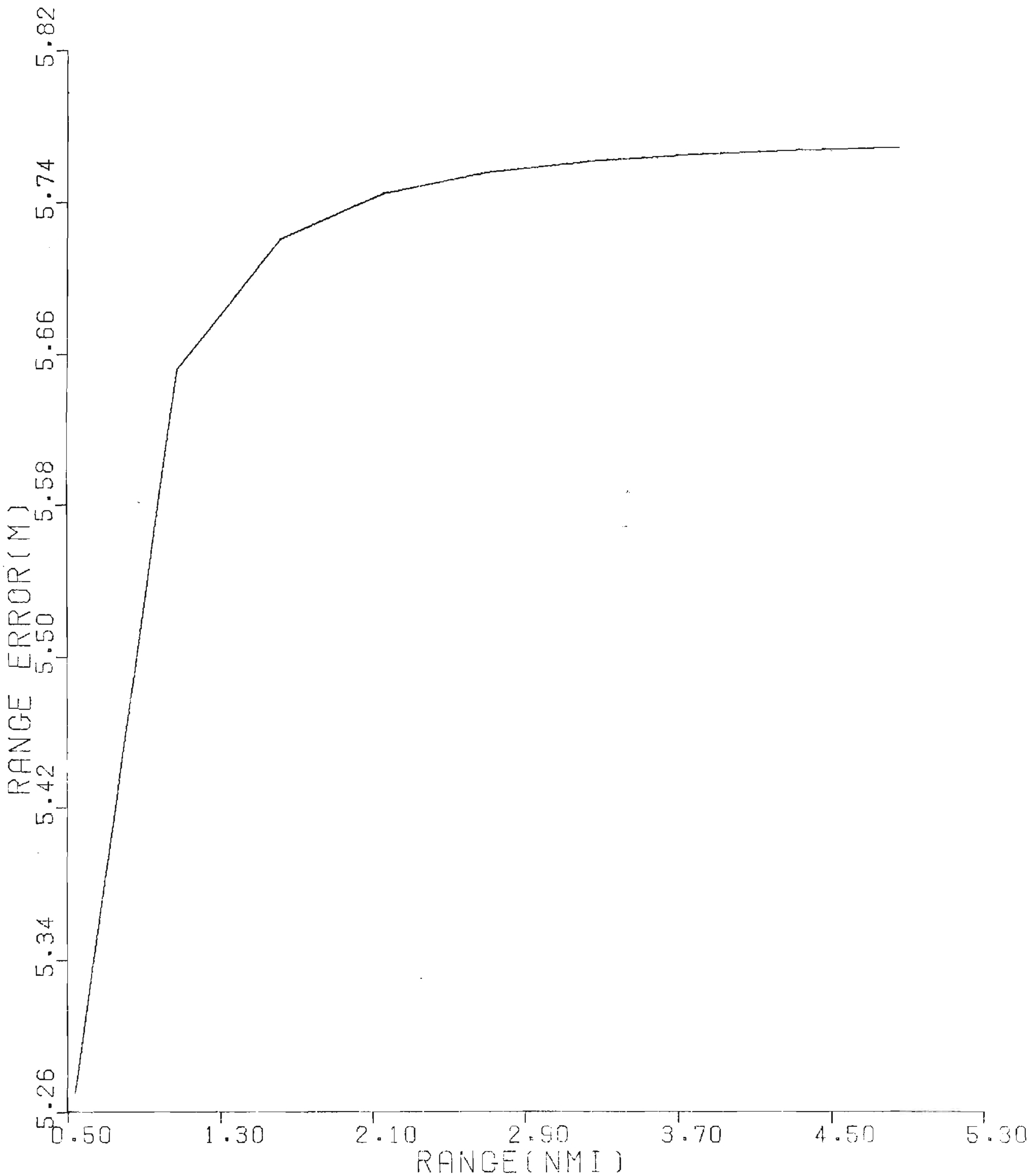
TPN-22 ANALYSIS



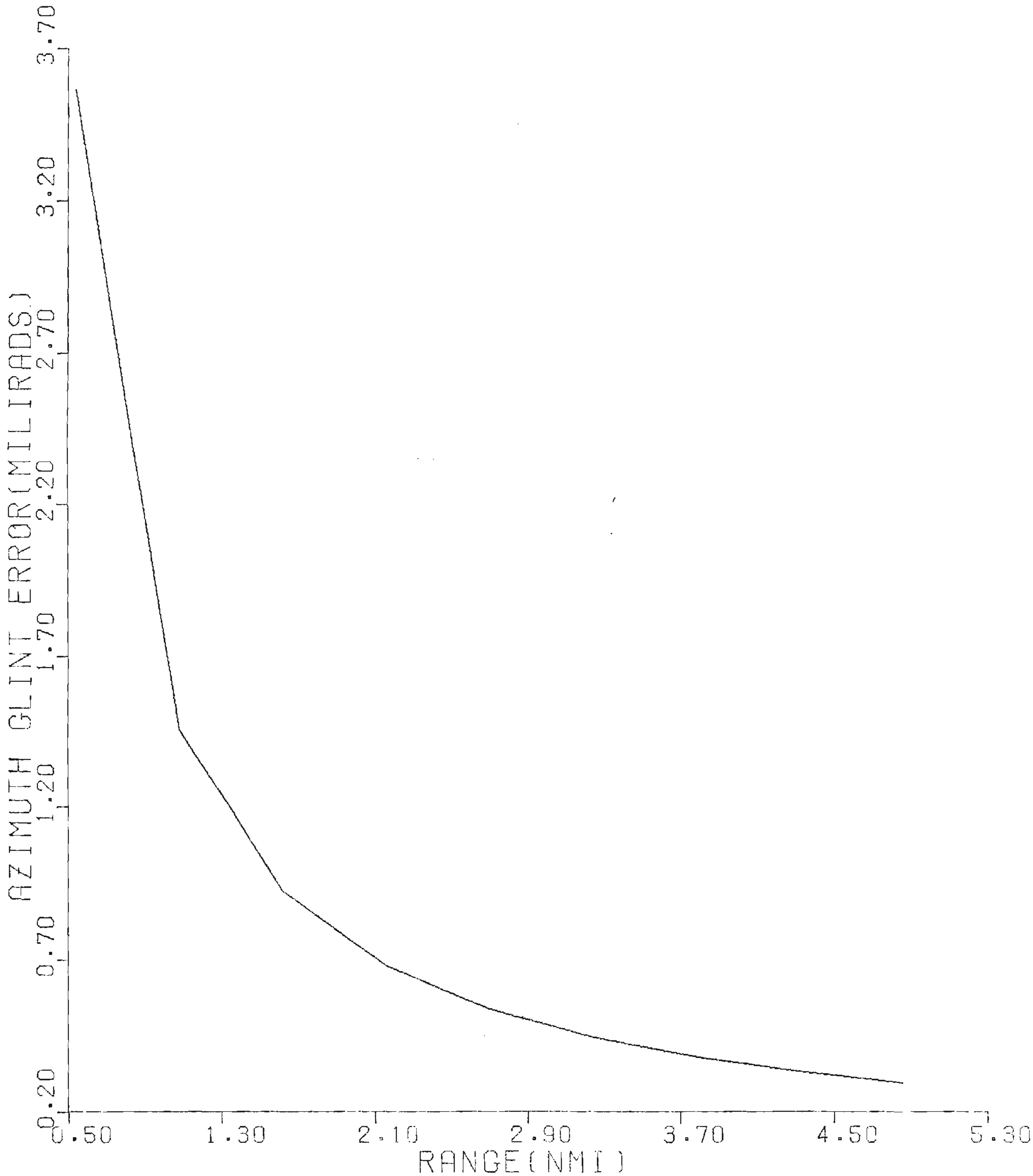
TPN-22 ANALYSIS



TPN-22 ANALYSIS



TPN-22 ANALYSIS



TPN-22 ANALYSIS